



Contents lists available at ScienceDirect

International Journal of Applied Earth Observation and Geoinformation

journal homepage: www.elsevier.com/locate/jag

Editorial

Towards effective application of geospatial technologies for disaster management

S U M M A R Y

This article provides an overview of the application of geospatial technologies for disaster and emergency management; the motive behind this special issue is focusing on the importance of highlighting the efforts of geospatial technologies community in the field of disaster and emergency management. This issue provides an insight on the future directions of geospatial technologies for disaster management. It starts with presenting the process of formalization of the idea behind this special issue, presenting the themes covered in this issue; summary statistics related to the submitted papers. The article provides an overview of the current state-of-the-art of geospatial technologies for disaster management with emphasis on GIS and the emerging web and mobile services. This editorial presents as much comprehensive user view of research directions from applications and applications development. This editorial concludes by providing a vision for geospatial technologies for disaster management and emergency response and briefly overview the content of this special issue.

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1. Introduction

The idea for proposing this special issue of the International Journal of Applied Earth Observation and Geoinformation on Geospatial Technologies for Disaster Management has evolved as a result of the growing and demonstrated need for adopting more effective geospatial solutions for saving life and property affected by the increasing number of disasters. The application of geospatial technologies in disaster and emergency management is on the rise; mainly due to the level of accessibility, reliability and effectiveness in providing accurate models and simulations of the real world phenomena. Geospatial technologies are capable of addressing both the spatial and the temporal aspects of disasters, which makes them effective decision support tools. All these factors have motivated the editors to propose selected themes for this special issue by focusing on:

- First, this issue is presenting original research papers that showcase the state-of-the-art of the application of geospatial technologies on different disaster and emergency management scenarios.
- Second, it is serving as a platform for future extension and possibly further emphases on the need for using spatial technologies in disaster management to the wider geospatial information community; particularly to the readership of the International Journal of Applied Earth Observation and Geoinformation. Some papers in this issue are addressing the links between different Geomatics technologies that are being used as input for developing geospatial databases.
- Third, this issue is providing an attempt to a case-study-based critical analysis of the gaps and deficiencies in the use of geospatial technologies for disaster management, with an aim to further stimulate future research in this important domain.

Since September 2008, the two guest editors have been working closely with the editor-in-chief and the editorial staff in producing this issue. The first call for papers was circulated in November 2008 and submissions were due by June 30, 2009. Initial review started on July 4, 2009 and completed by November 2009 allowing authors about 3-month period to revise and resubmit. The second review cycle commenced in February 2010 and completed by the end of May 2010. The topics targeted by the call for papers are: interoperable solutions for disaster and emergency management; geo-ontology and semantics for emergency response; spatial sensor web for risk and disaster monitoring; 3D visualization of scenes and situations on different mobile front-ends; P2P geospatial web services for emergency response; spatial decision support systems for disaster management; multidimensional dynamic simulation in support of disaster management; exploratory visualization for multi-hazard risk assessment; real-time 3D GIS for emergency response; and SDI stakeholder involvement in disaster management operations. This issue features articles in a range of important themes covering many of the topics listed in the call for papers, which are: hazard mapping; ontology and feature search for real time notification; improved situational awareness in fire emergency; spatial decision support systems (SDSS) for earthquake induced landslide and the application of hydraulic modeling to levee failure; remote sensing for flood modeling; and geospatial data resource issues.

The review process was a cumbersome task, mainly due to the difficulty of finding the right reviewers to judge on the submissions. The specialized application-based nature and scope of this special issue makes it more difficult, as there are only very few experts in the field with interest in dedicating efforts and time to provide feedback for authors. A total number of 19 papers were submitted for consideration in this special issue, of which 10 papers are now included in this special issue. One hundred and ninety-five review-

ers were invited to this special issue, of which about 50 have kindly accepted the task to provide assessment on the submitted papers. The average review time taken was 19 days and the maximum time taken was 80 days for providing specific detailed feedback according to the journal policy.

2. Why geospatial technologies for disaster management?

Disaster management is an interdisciplinary science that attempts to utilize various procedures and techniques for monitoring and analysis of different disaster management parameters, with aim to reduce or eliminate the loss that might occur. Disasters are managed through a four phase cyclic process known as the disaster management cycle, which is comprised of: preparedness, response, recovery and mitigation. The preparedness phase deals with understanding the needs that might help with addressing the situation at hand should a disaster occur. In the response phase, all efforts are dedicated to providing timely support and relief. The recovery phase is the back to normal phase where all efforts are dedicated to restoring services and ensuring business continuity. The last phase is the mitigation phase which deals with mitigating the impact from future disasters.

The application of geospatial technologies for disaster management has provided the ease of producing meaningful information products that can otherwise be time and resource intensive. Modeling, simulation and visualization of geospatial data provides disaster management decision makers with the ease of using embedded information in effective knowledge generation and decision support process, on the basis of modeling geospatial data.

3. Challenges for the application of geospatial technologies for disaster management

The effective application of geospatial technologies for disaster and emergency management is faced by significant challenges. These challenges are mostly operational, policy and applications related. Challenges motivate for more advanced research in order for Geospatial Technologies for Disaster and Management community to be able to provide optimum solutions for the daily rising demand for efficient solutions. It also requires high levels of systems and operational interoperability and the effective capacity building to improve or enhance current capacities mainly for vulnerable communities.

Challenges in the operational side include the lower levels of interoperability, lower data integration capabilities and conflicting stakeholders' needs and expectations. These challenges are among many that limit the complete utility of geospatial information for disaster and emergency management. In particular, it makes the process of sharing, analyzing or acquiring specific datasets for specific application a difficult task. Other challenges relate to the adoption of common geospatial standards, such as those of the Open Geospatial Consortium (OGC). OGC standards are now widely adopted and usable in disaster and emergency management. However, still there are many areas that lack interoperability. The development on standards and interoperability side will contribute to the development in the mobile geospatial applications side, specifically handheld systems, which provide effective means for disaster and emergency management, in particular in field data collection.

The most significant policy challenge is securing consistent access to geospatial data from different parts of the world. The United Nations Office for Outer Space (UNOOSA) is leading global efforts in standardizing the process of sharing global data during disasters called the International Charter "Space and Major Dis-

asters". This is in addition to the conflicting interests for disaster management stakeholders during extreme situations, where efficient models are highly needed.

On the applications side, challenges are in the limited geospatial data modeling and processing capabilities in different parts of the world and constraints of internet bandwidth as well as the availability of trained human resource all have lead to in-effective disaster and emergency management process in many parts of the world. However, this cannot be isolated from development level and technology priorities, which represents the other side of the issue. It is noticeable that web geospatial applications have started to emerge widely, as they provide interoperable means for decision makers to access situational awareness models at multiple locations, simultaneously. This includes multidimensional modeling and simulation, virtual reality modeling and visualization.

4. The future of geospatial technologies for disaster management

Disaster management community will continue to explore new means of data integration, modeling and simulation, as the advances in geospatial technologies continue. Considerable developments are expected to emerge in spatially enabled integrated incident management and response systems, where different multi-modalities of spatial information systems can be used to provide multi-tier modeling, simulation, processing and visualization in handheld devices, on computer screens and on large displays in Emergency Operation Centers (EOCs), including virtual reality modeling and simulation. Among the growing trends in information technology, geospatial information technologies for disaster and emergency management are the techniques that combine data visualization with human factors to provide effective analytical and decision support approaches, also known as "geovisual analytics". This application area is on the rise and provides disaster and emergency management community with near real-world simulations for displaying and analyzing large and heterogeneous volumes of datasets. Finding effective means for field data collection, for better data and systems integration, for rapid analysis of most emerging 3D data including LIDAR, and for providing fast and feasible solutions for Disaster Management Location Based Services (DM-LBS), includes issues like addressing multi-tier vulnerability analysis and assessment. There is a need for a broader scope for using public participation GIS (PPGIS) for disaster and emergency management. This will help with acquiring geospatial data, data analysis and processing.

For keeping with the advances in geospatial technologies for disaster management, the editors would recommend publishing a new journal dedicated for geospatial technologies for disaster and emergency management.

5. About this special issue

The wide range of topics covered in this special issue has highlighted some of the areas of progress in the use of geospatial technologies for disaster management. The ten accepted and selected articles cover wide range of applications integrating all the themes of spatial technologies including GIS, Remote Sensing, Photogrammetry and GPS. All published articles highlight cutting-edge research, as following:

- The first article is entitled: Automatic search of geospatial features for disaster and emergency management. This paper discusses the limitations and the fast development of OGC Web Feature Service (WFS) technologies has undoubtedly improved the sharing and synchronization of feature level. It proposes a

framework for helping emergency responders and disaster managers find new ways of efficiently searching for needed geospatial information at the feature level using Geospatial Semantic Web technologies and natural language interfaces.

- The second article is entitled: Simulation and analysis of infrastructure interdependencies using a Petri net simulator in a geographical information system. This paper introduces a Petri net into a geographical information system to develop the GeoPetri Net system, which can be used to simulate the complex geographical relationships among places and nodes. It supports disaster management operational and decision makers a like in dealing with the complexity of infrastructure networks through simulation and modeling in the effective response and management of resources for rescue, recovery, and restoration.
- The third article is entitled: Real-time notification and improved situational awareness in fire emergencies using geospatial-based publish/subscribe. This paper proposes geospatial-based interaction framework that serves as a middleware for real-time transacting of spatially-related information of interest. It provides means for emergency agencies seek to maintain situational awareness and effective decision making through continuous monitoring of, and real-time alerting about, sources of information regarding current incidents and developing fire hazards.
- The fourth article is entitled: Web-based terrain and vector maps visualization for Wenchuan Earthquake. This paper presents a Web-based three-dimensional Geographic Information System (3DGIS) for Wenchuan Earthquake disaster simulation. The application aims to interactively represent and transfer large spatial objects of Wenchuan County, China, as well as for dynamically rendering them in networking environments. Level-of-detail (LOD) terrain models and vector maps are created, and the server-client architecture is presented. The application provides disaster and emergency management decision makers with an effective way for powerful access and manipulation of large-scale Wenchuan datasets.
- The fifth article is entitled: Development of a spatial decision support system for monitoring earthquake-induced landslides based on aerial photographs and the finite element method. This paper presents a Spatial Decision Support System (SDSS) by incorporating aerial photographic data, GIS techniques, field investigations, and finite element geomechanical modeling. It analyses the mechanisms of the Hungtaiping landslide, which was induced by the 1999 Chi-Chi earthquake. The landslides SDSS can help determine model parameters, evaluate slide mechanisms and remediation measures, and predict slope behavior for a subsequent earthquake event.
- The sixth article is entitled: Assessment of an ASTER-generated DEM for 2D Hydrodynamic Flood Modeling. This work has investigated the flooding characteristics in the data scarce region of the Lake Tana basin at the source of the Blue Nile River. The study required to integrate remote sensing, GIS with a two-dimensional (2D) module of the SOBEK flood model. The paper provides decision support means for Disaster Management decision makers by providing flood forecasting models which often provides input to flood hazard preparedness and mitigation.
- The seventh article is entitled: Satellite-Based Damage Mapping Following The 2006 Indonesia Earthquake - How Accurate Was It? This paper evaluates the accuracy and completeness of the damage maps produced based on the data obtained as a result of activation of the International Charter "Space and Major Dis-

asters". Most of the acquired images were processed by UNOSAT and German Space Agency's Center for Crisis Information (DLR-ZKI), while substantial damage using ground damage information collected during an extensive survey in the weeks following the earthquake. The map accuracy evaluation is discussed in the wider context of image-based damage mapping.

- The eighth article is entitled: Tight integration of persistent scatterer InSAR and GPS observations for detecting vertical ground motion in Hong Kong. This paper introduces a method for tightly integrating GPS observations and the persistent scatterer (PS) interferometric synthetic aperture radar (InSAR) is proposed to detect vertical ground motion in Hong Kong, China. Results obtained show that the method is capable of detecting accurately the vertical ground motion.
- The ninth article is entitled: Using multi-temporal remote sensor imagery to detect earthquake-triggered landslides. This paper proposes an automated method for detecting the spatial distribution of earthquake-triggered landslides by examining after event vegetation changes. Central to this method is the use of pre- and post-event remote sensor images covering the same area. Geometric correction and radiometric normalization are performed before deriving a vegetation index from each image. This paper provides disaster management prediction of catastrophic landslide activities.
- The tenth article is entitled: Surface deformation associated with the 2008 Ms8.0 Wenchuan Earthquake from ALOS L-band SAR interferometry. This paper presents an approach for mapping surface deformation caused by the main shock with the interferometric synthetic aperture radar (InSAR) technology. The catastrophic event caused significant surface ruptures and permanent ground displacement in a wide area. The introduced approach provides a means for disaster management mapping large spatially distributed events.

Acknowledgement

The editors would like to acknowledge the support provided by the JAG editorial board, specifically, Professor Alfred Stein and Ms. Teresa Brefeld for their extended support. Extended support from Elsevier staff and Elsevier Editorial System Technical support team is acknowledged. Finally, this issue would not have been possible without the great support from our reviewers, with thank them for their time, patience and diligence. Special thanks to all those who considered this special issue, and we hope that we have contributed to providing positive experience to all those who have considered this special issue.

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UNCLASSIFIED

DOCUMENT CONTROL DATA (Security classification of the title, body of abstract and indexing annotation must be entered when the overall document is classified)		
1. ORIGINATOR (The name and address of the organization preparing the document, Organizations for whom the document was prepared, e.g. Centre sponsoring a contractor's document, or tasking agency, are entered in section 8.) Publishing: DRDC 1133 Sheppard Ave West , Toronto, ON Toronto M3M 3B9 Performing: DRDC Toronto Monitoring: Contracting:		2. SECURITY CLASSIFICATION (Overall security classification of the document including special warning terms if applicable.) UNCLASSIFIED
3. TITLE (The complete document title as indicated on the title page. Its classification is indicated by the appropriate abbreviation (S, C, R, or U) in parenthesis at the end of the title) Editorial Article: Towards Effective Application of Geospatial Technologies for Disaster Management (U) (U)		
4. AUTHORS (First name, middle initial and last name. If military, show rank, e.g. Maj. John E. Doe.) Rifaat M. Abdalla; Jonathan J. Li		
5. DATE OF PUBLICATION (Month and year of publication of document.) December 2010	6a NO. OF PAGES (Total containing information, including Annexes, Appendices, etc.) 2	6b. NO. OF REFS (Total cited in document.)
7. DESCRIPTIVE NOTES (The category of the document, e.g. technical report, technical note or memorandum. If appropriate, enter the type of document, e.g. interim, progress, summary, annual or final. Give the inclusive dates when a specific reporting period is covered.) Scientific Literature Published in the International Journal of Applied Earth Observation and Geoinformation 12 (2010) 405–407		
8. SPONSORING ACTIVITY (The names of the department project office or laboratory sponsoring the research and development – include address.) Sponsoring: Tasking:		
9a. PROJECT OR GRANT NO. (If appropriate, the applicable research and development project or grant under which the document was written. Please specify whether project or grant.)	9b. CONTRACT NO. (If appropriate, the applicable number under which the document was written.)	
10a. ORIGINATOR'S DOCUMENT NUMBER (The official document number by which the document is identified by the originating activity. This number must be unique to this document) DRDC Toronto SL 2010–135	10b. OTHER DOCUMENT NO(s). (Any other numbers under which may be assigned this document either by the originator or by the sponsor.)	
11. DOCUMENT AVAILABILITY (Any limitations on the dissemination of the document, other than those imposed by security classification.) Unlimited distribution		
12. DOCUMENT ANNOUNCEMENT (Any limitation to the bibliographic announcement of this document. This will normally correspond to the Document Availability (11). However, when further distribution (beyond the audience specified in (11) is possible, a wider announcement audience may be selected.)) Unlimited announcement		

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(U)	Not available.
14. KEYWORDS, DESCRIPTORS or IDENTIFIERS	(Technically meaningful terms or short phrases that characterize a document and could be helpful in cataloguing the document. They should be selected so that no security classification is required. Identifiers, such as equipment model designation, trade name, military project code name, geographic location may also be included. If possible keywords should be selected from a published thesaurus, e.g. Thesaurus of Engineering and Scientific Terms (TEST) and that thesaurus identified. If it is not possible to select indexing terms which are Unclassified, the classification of each should be indicated as with the title.)
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